Development of a wavelength-shifting fiber-based light collector for the new photodetector of IceCube-Gen2

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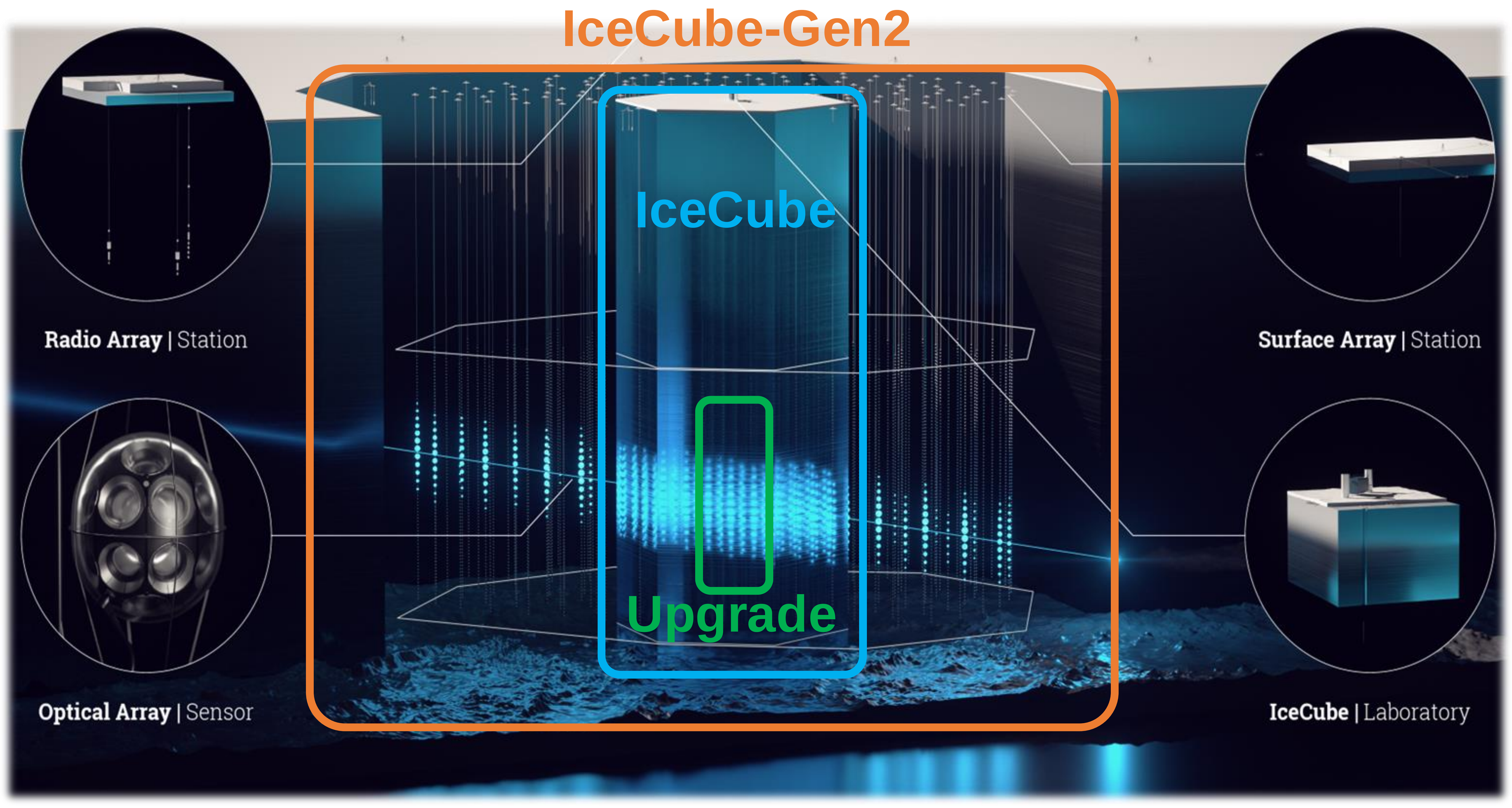
IceCube-Gen2



Photodetector

IceCube

DOM

- ✓ Number of PMTs : 1
- ✓ About 5,000 DOMs are deployed along 86 strings
- ✓ Instrumented volume 1 km^3

IceCube Upgrade

mDOM & D-Egg

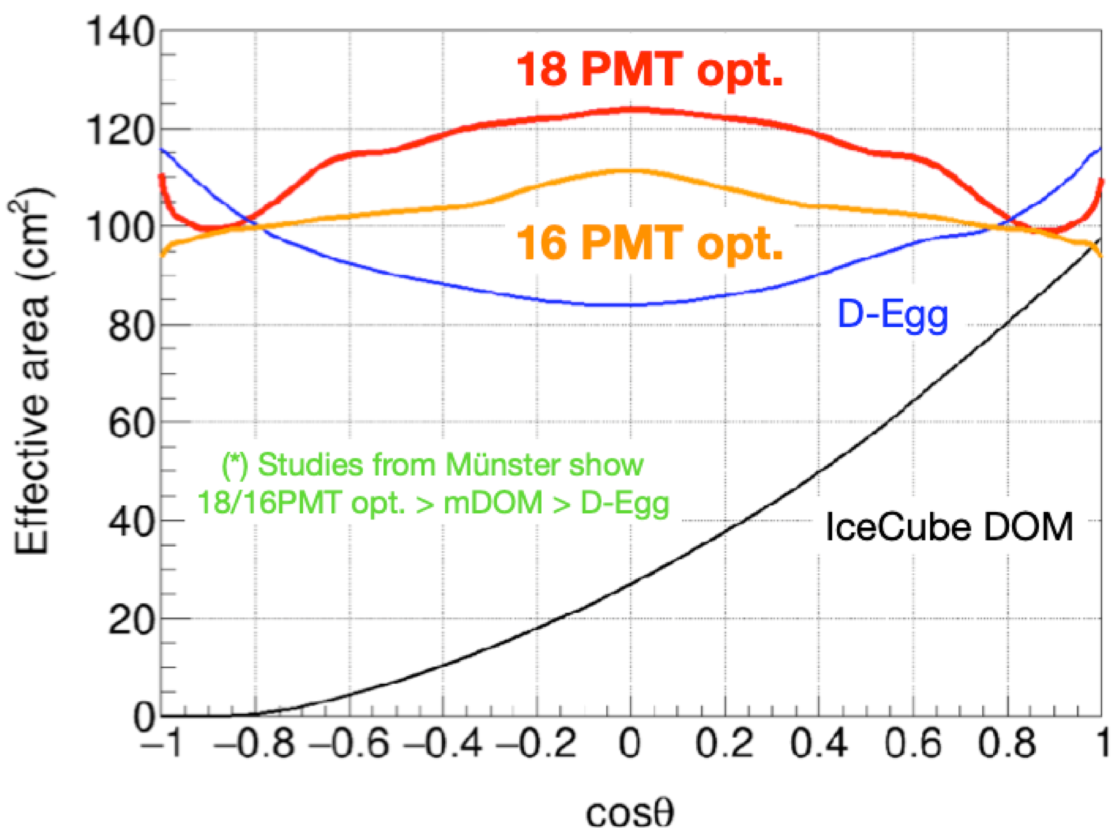
- ✓ Number of PMTs mDOM : 24, D-Egg : 2
- ✓ About 700 detectors (mDOM : 402, D-Egg : 277) will be deployed along the new 7 strings

IceCube-Gen2

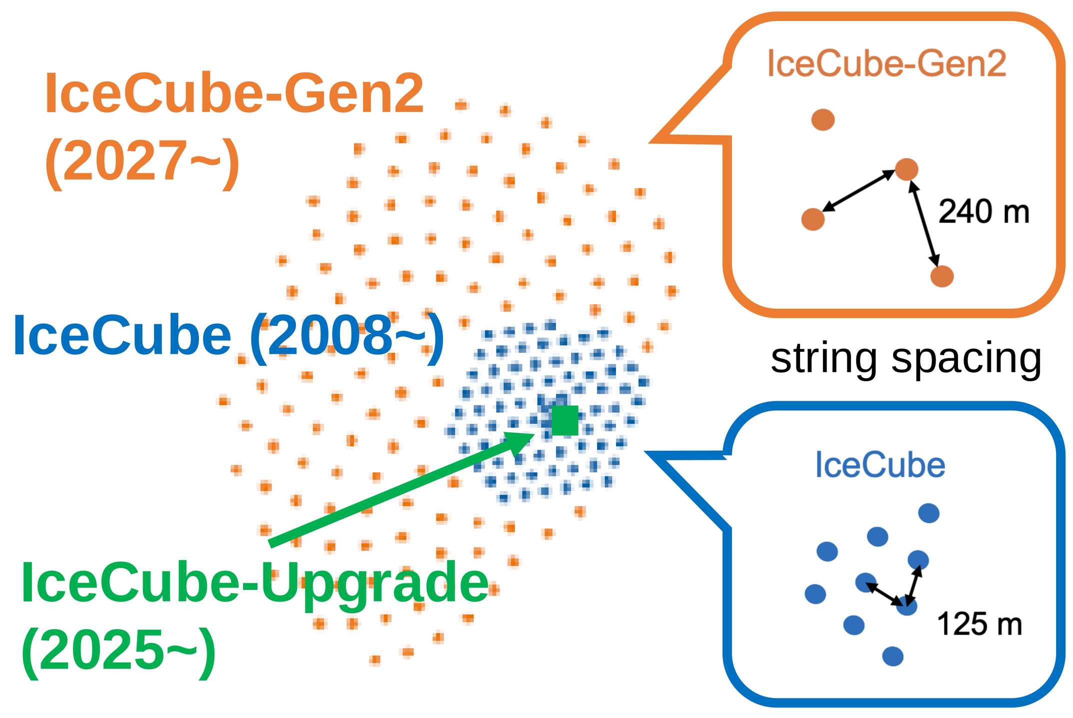
LOM

- ✓ Number of PMTs : 18
- ✓ About 10,000 LOMs are deployed along the new 120 strings
- ✓ Instrumented volume 8 km^3

Effective area

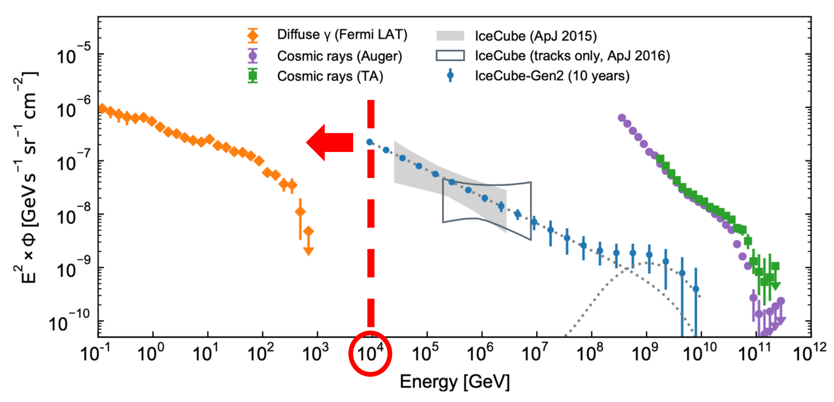


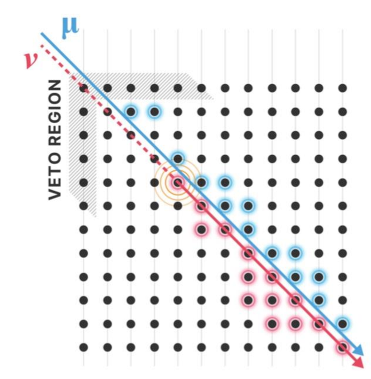
Optical Array

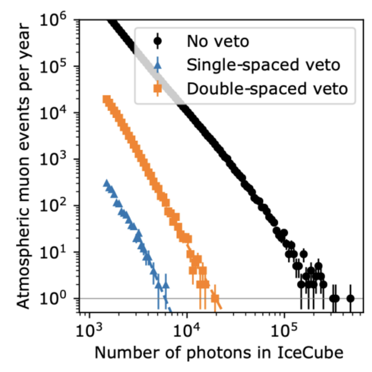


Challenges

- ✓ Attenuation length of Cherenkov light in water is 120 m
  → The number detectable photon decrease by a factor of about e^{-1}
- ✓ The threshold of detectable neutrino energy is increased
  → 10 TeV
- ✓ Events triggered by the outer layer of IceCube are identified as atmospheric muons (Veto)
- ✓ Veto ability will decline



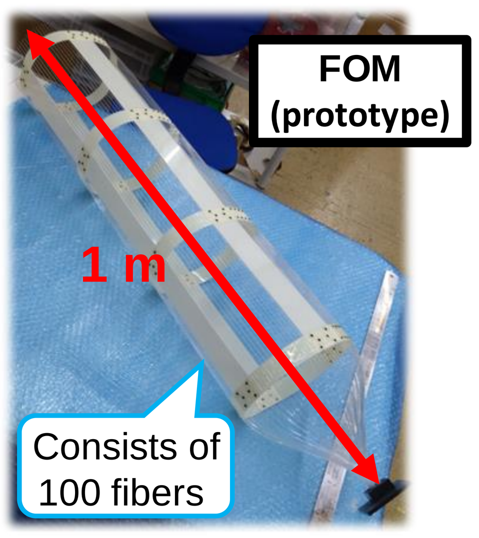


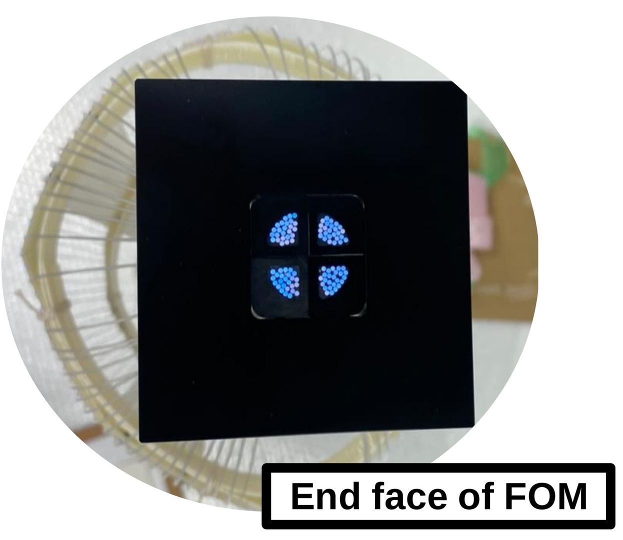


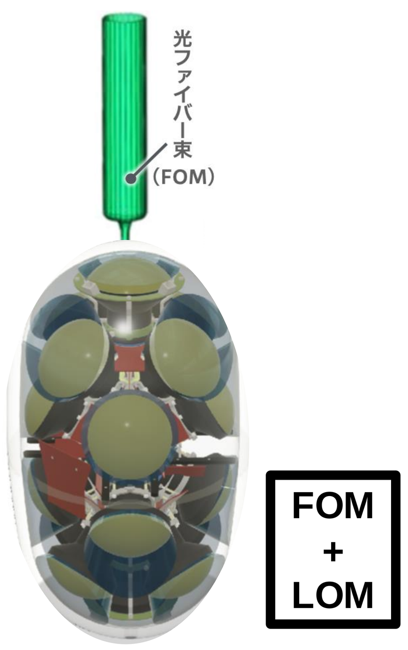
FOM (Fiber Optic Module)

Concept

✓ To solve this problem, we propose a new approach to increase the effective area at low cost : a WLS fiber-based light collector (FOM) is connected to the LOM

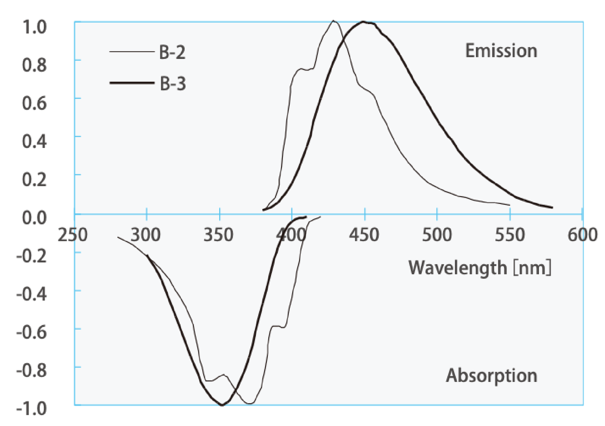




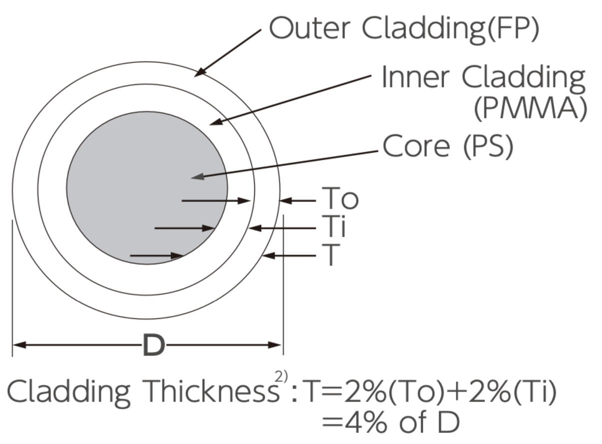


WLS fiber - Kuraray's plastic scintillating fibers

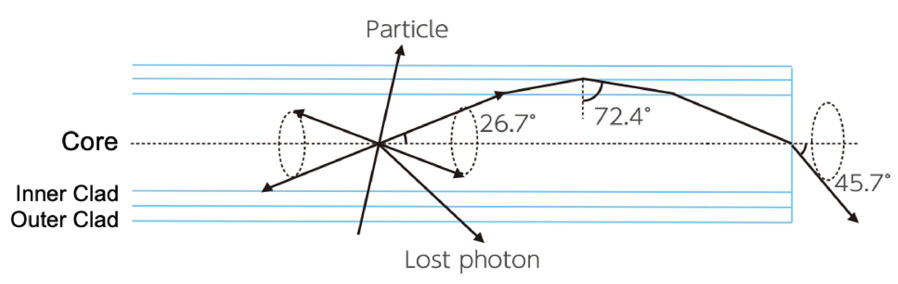
✓ WLS (UV to Blue shifter)



✓ Double Clad

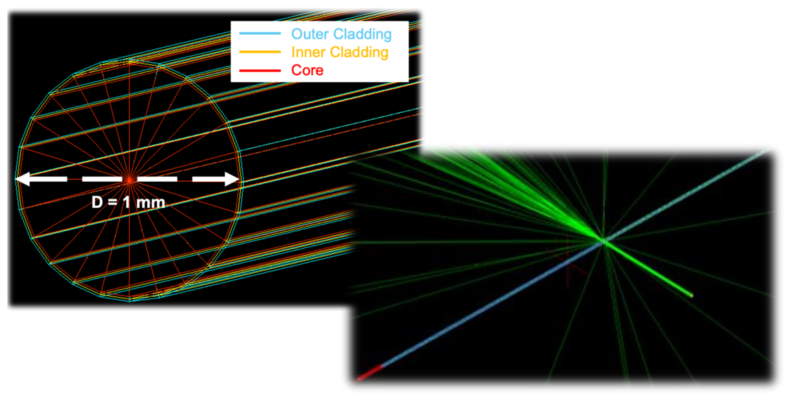


	Materials	Refractive index	Density (g/cm^3)
Core	Polystyrene	1.59	1.05
Inner Cladding	Polymethyl methacrylate	1.49	1.19
Outer Cladding	Fluorinated polymer	1.42	1.43

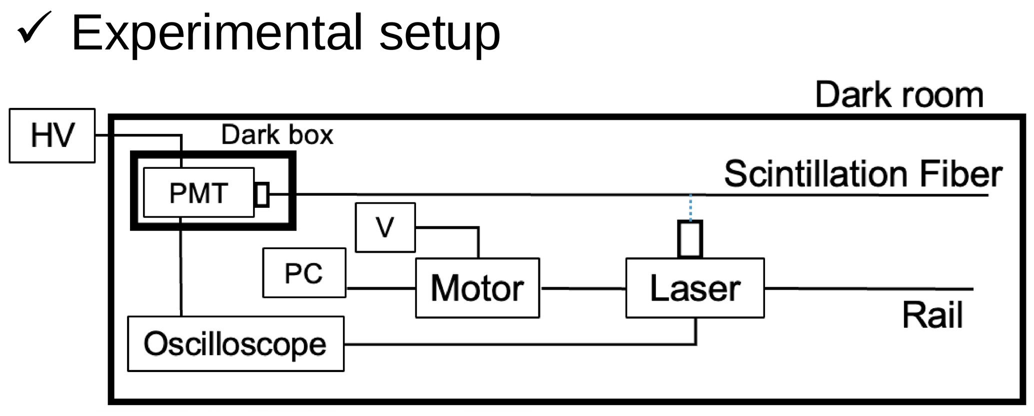


Simulation & Experiment

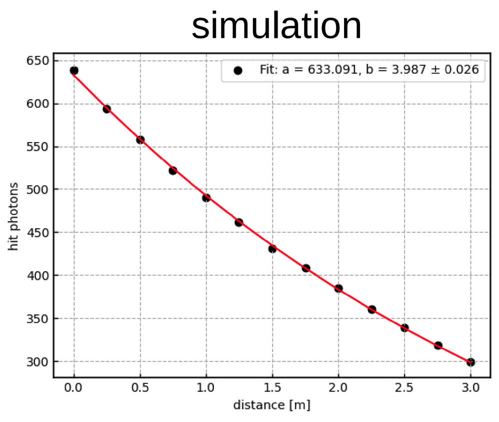
✓ Gerant4 simulation

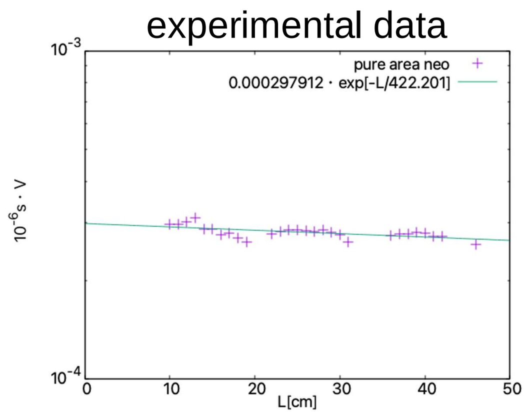


✓ Experimental setup



✓ Attenuation length



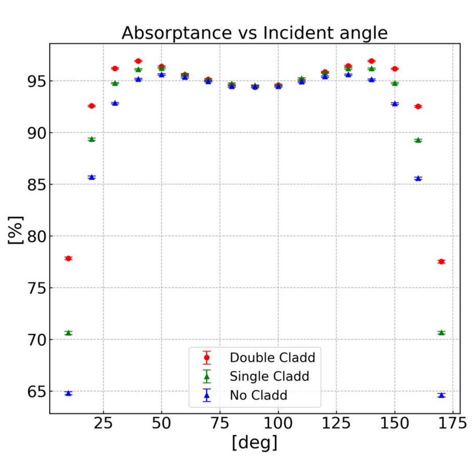


Fit function

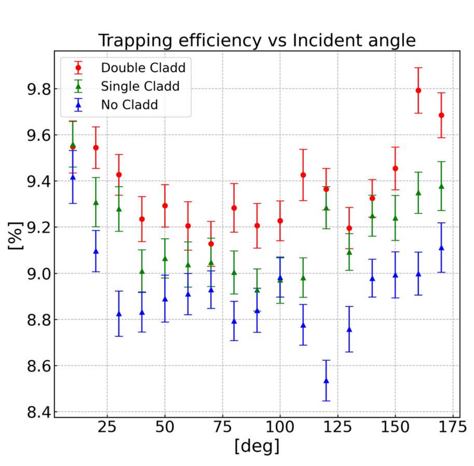
$f(x) = a\exp\left[-\frac{x}{b}\right]$ (b : Attn. Length)

catalog : b > 4.00 m
simulation : b = 3.987 $\pm$ 0.026 m
data : b = 4.22 m

✓ Absorptance & Trapping efficiency

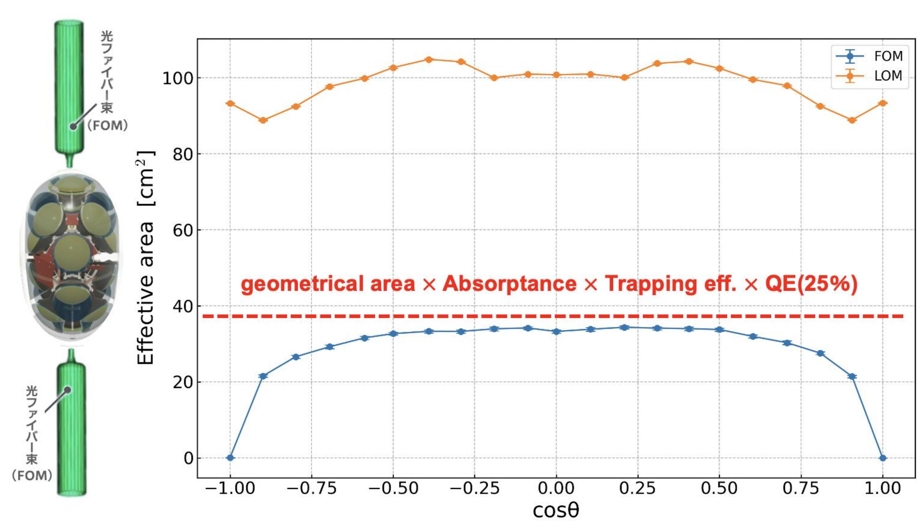


No Clad → Single Clad	1.50 % up
No Clad → Double Clad	2.72 % up
Single Clad → Double Clad	1.20 % up



No Clad → Single Clad	2.70 % up
No Clad → Double Clad	4.98 % up
Single Clad → Double Clad	2.22 % up

✓ Effective area



→ It is estimated that connecting two FOMs to LOM will increase the effective area by 20 ~ 30 %